Natural Gas Programs Summary

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Natural Gas Programs Summary

- Currently VPTNA has two natural gas engine programs partially funded by the National Renewable Energy Laboratories (NREL) and the South Coast Air Quality Management District (SCAQMD) to develop natural gas engines that meet 2010 emissions standards.
- Both utilize three-way catalyst (TWC) technology in combination with chemically correct combustion, and exhaust gas recirculation to reduce emissions. Use of these technologies leverages all the research done with light-duty gasoline.
- Improved efficiency is being explored based on the corporation's world 11-liter diesel engine platform using Variable Valve Actuation (VVA) technology to remove the throttle and optimize valve events. The throttle is the main contributor to efficiency loss with NG engines.

Program Summary cont.

- The VVA program is a technology demonstration only, with a NOx emissions target of 0.2g/bhp-hr. It will also identify combustion technology needs.
- The second program will transfer technologies developed using the Mack E7G blended with the technology from the above program. The 11-liter platform will be used to demonstrate the TWC technology at 2010 emissions levels in the field in two Waste Management refuse haulers. Chassis demonstration will begin during the first quarter 2006 and run for 6 months in CA. The demonstration is partially sponsored by the SCAQMD.
- The Power rating target is 325 hp @1950 rpm and 1180 lb-ft of torque @1250 rpm for compatibility with the Allison automatic “World Transmission” most commonly used in refuse applications

Emissions Results: Mack E7G with TWC

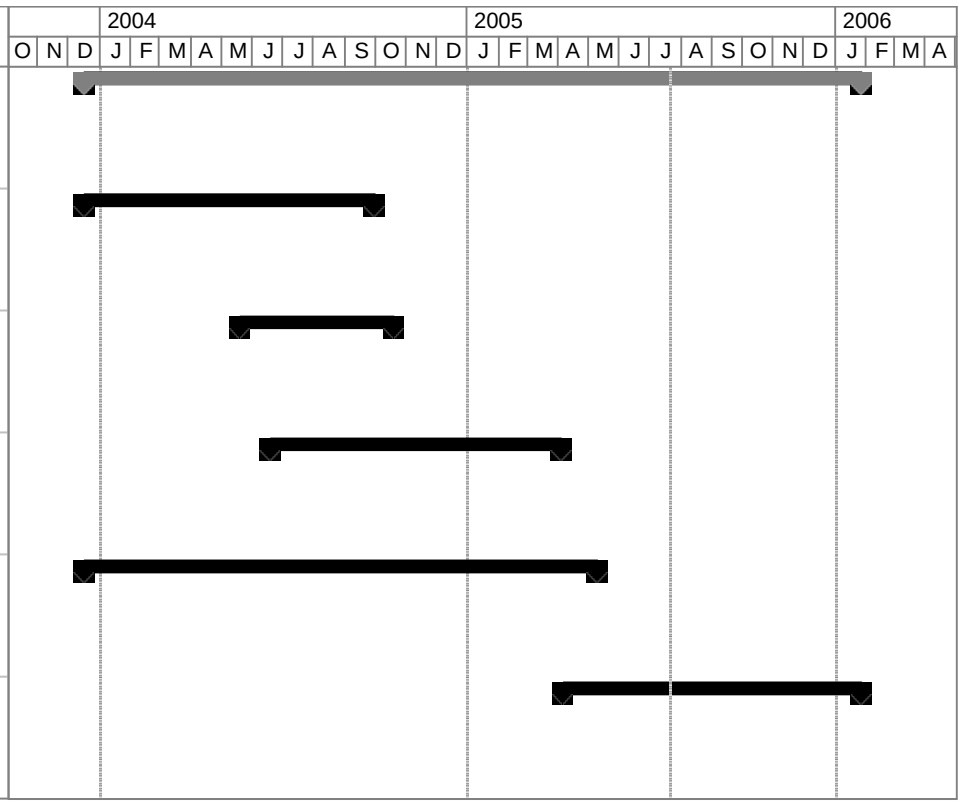
Emission (g/bhp-hr)	FTP	OICA	2010
NOx	0.049	0.040	0.2
THC	0.435	.0200	NA
CO	4.153	2.000	15.5
NMHC	0.000	0.000	0.14
PM	0.002	0.000	0.01
BSFC (lb/bhp-hr)	0.441	0.336	

-De-greened TWC (125 hours run time)

--2% fuel penalty over the E7G (Lean Burn) @ 2.0 g/Bhp-hr NOx

11-liter VVA Engine Preparation

ID	Task Name
0	**Schedule - NREL/VPT 32050**
1	**Engine & Subsystem Specifications**
4	**Parts Design & Adaptation**
11	**Parts Manufacturing & Prototype Engine Assembly**
19	**Sturman VVT Design & Manufacturing**
36	**SwRI Engine Interfacing, Installation & Validation**



Plan for 11-liter VVA Testing

SwRI Engine Interfacing, Installation & Validation	April	May	June	July	August	September	October	November	December
Install Engine									
Install HVA System									
Debug Systems									
A/F Ratio and EGR Distribution									
Baseline Testing									
Engine Mapping*									
Catalyst Evaluation									
Performance & Emissions Validation									

Status

- VEHICLE DEMONSTRATION:
  - Engineering the 11-liter into the Mack MR chassis
  - Preparing the 11-liter for development to US10 emissions level

- VARIABLE VALVE DEVELOPMENT
  - Engine in test cell at SwRI.
  - Baseline testing underway.